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Analysis of The Dynamic Stability Positioning Control System of Semisubmersible

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Abstract* – The semisubmersible offshore dynamics depend on the condition of the ocean environments. Disruption of forces and moments in the floating structure caused by environment factors, there are wind, waves and ocean currents. This disturbances will cause decreased stability of the structure. This situation will disrupt the process of oil and gas exploration. Currently exploration activities is success if the structure in the static condition and remain on. This condition needs a force or torque to counter the disruption caused by the environment. This paper proposes a control system and analyze the performance of response stability of dynamic positioning system (DPS). DPS will control in 3 Degree of Freedom (DOF) variables, there are: sway, roll and yaw. The structure of the DPS consists of controllers, sensors, actuators. Actuators are Thruster System and Power System. The strategic to maintain in DPS is Linear Quadratic (LQG) control. This method is one of optimal control which capable rejected wave interference. Some values control parameters, that are Q and R in the cost function, show the robustness of DPS.

***Index Terms* – DPS, LQG, Q dan R, platform offshore.**

INTRODUCTION

Offshore platforms is maintained at stationary condition of dynamic stability. This condition in the position and orientation desired. The platform is equipped with the appropriate propulsion systems to compensate for the power of ocean waves, wind and currents induced.

Platform is a nonlinear dynamics model, this is caused by the shape of the hull is stiff and strong ocean hydrodynamic interactions [1]. Non-linear models such require a control system that is able to estimate the values of parameters, so that the control signal is able to cope to the uncertainty of parameter changes

The control system is used to determine the appropriate balancing force, when the floating building is shift or change to its orientation. Control systems have a robustness due to environmental influences. The performance control is needed to maintain the stability of the position [1].

In some floating structures and vessels, anchors is used to stabilize their position. The controller to compensate force and moments of anchor, so floating objects in expected position. Variables of structure dynamics shown in 6 dof. Control variables are surge, sway and orientation (yaw) as expected [2]. In other scenario, the DSP control variables are surge, sway and yaw [3]. Control strategy in various types, ie: a conventional and based on expertise. Some strategies for dynamic positioning control system has been proposed by some researchers, which control system PID - ANN, fuzzy logic control system [2]. Dynamics positioning system is a control system that determine to what position and direction stability conditions [5].

MATERIAL AND METHOD

The design of the control system, starting with determination of the platform dynamic models. Model dynamics is expressed in the 3 d.o.f., ie; sway, roll, and yaw variables. The case studies carried out on the Atlantis PQ semisubmersible rig platform. Platform dynamics model is derived based on the vessel models [5].

Non linear models of spring-mass-damper as analogy of platform structure can be used as a reference model in PID control system [6]. The model in the polynomial transfer function of s. The state space equation models is used in optimal control system design. This system is expected to provide optimum signal value on rotation azimuth thruster [7].

Dynamics equations is expressed in the following form: in sway, roll and yaw motion.

$$m[\dot{v} - Y_G(r^2 + p^2) + Z_G(-\dot{p}) + X_G(\dot{r})] = Y \quad (1)$$

$$I_x\dot{p} + m[Y_G(vp) - Z_G(\dot{v})] = K \quad (2)$$

$$I_z\dot{r} + m[X_G(\dot{v}) - Y_G(-vr)] = N \quad (3)$$

The third equation (1) – (3) is formed in the state space equation of (4).

$$\mathbf{M}\dot{\mathrm{v}} + \mathbf{D}\mathrm{v} = \tau_L \quad (4)$$

M: inertia matrix, D: damping matrix and τ_L is force and torque of actuator. The actuator is thruster as DPS components. The type of thruster in the design of control is *Rotatable (Azimuth) Thruster*.

The model is approached with slender body theory. The model transformed in the form of non-dimensional using the bis system [8]. The form of equation (4) with the disturbance factors is expressed in the equation (5),

$$\boldsymbol{M}\dot{v}_L + \boldsymbol{D}v_L = \tau_L + w_L \quad (5)$$

Where w_L is environment factors.

LQG is composed of Linear Quadratic Regulator and Kalman Filter. Block diagram of LQG is shown in the Figure 1.

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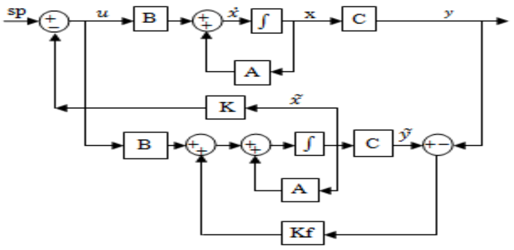

Figure 1. LQG control

The matrix of A, B, C is resulted from state space equation models. A is matrix of system, B is input matrix and C is output matrix. K is gain of control and Kf is gain Kalman filter.

RESULT

The variation of gain parameter of LQG controller is shown in Table 1. The minimal cost function – J when the Q = R = 0.00001.

Table 1. The value of gain parameter of LQG control and cost function J

No	*Q*	*R*	J
1	20	10	0.0622
2	15	10	0.0530
3	10	10	0.0481
4	5	10	0.000309
5	5	5	4.670122
6	0.0001	0.0001	0.000129
7	1	0.1	34.663000
8	1	0.01	40.846242
9	1	0.001	43.3291900
10	1	0.0001	46.194800

Response of yaw and sway motion when the wave disturbances is shown in figure 2 and 3.

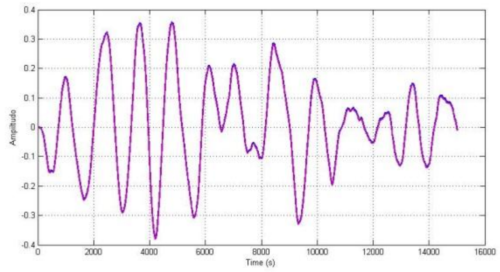

Figure 2. Sway response of platform in wave disturbances.

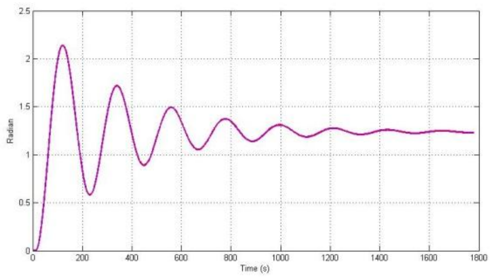

Figure 3. Yaw response of platform in wave disturbances.

CONCLUSION

From the results and discussion that has been Described in above, it can be concluded that:

1. The design of gain regulator K and gain of Kalman Kf for each value of Q = 0.0001, R = 0.0001 and value Qn = 0.001, Rn = 0.001.
2. LQG control system is able to take action to control the interference waves and gaussian so that platforms are still able to follow the set point.
3. Error steady state is small and in the limit of critical tolerance.

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